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Investigation on mechanical characterization of Al/Mos2/WC hybrid composite

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ABSTRACT

In the present research, Aluminium (Al6262) is chosen as matrix, Tungsten Carbide (WC) and Molybdenum Disulphide (MoS2) particulates as primary and secondary reinforcements in different weight fraction. The MMCs are fabricated by stir casting method with mechanical stirring arrangement. The Molybdenum Disulphide (MoS2) particulate was added in various proportions of 2%, 4 % and 6% on mass fraction and also added WC particulates at 4 %, 8 % and 12 % on mass percentage basis to the molten metal. For various created composites, experimental data such as Charpy Impact test, micro hardness,tensile and microstructural characterisation was analyzed. The distribution of WC particles and MoS2 in the base matrix was investigated microstructurally. The results revealed that increasing the weight fraction of WC and MoS2 increases the tensile, hardness and impact strength of the produced MMCs.

1. Introduction

Recent improvements in materials, notably low density and very light weight materials with good durability, toughness, and stiffness, have been made in the industrial and aerospace industries. Composites are one of the most important advanced materials [1]. In general, one helping us achieve as a matrix for distributing the reinforcing phase. This is especially true with MMCs, because the act of integrating a reinforcement that can produce changes throughout the metallurgical matrix's structures [2]. In light of the aforementioned specifications, the proposed study would create a TiC-Al6082 hybrid composite which are fabricated through stir casting method because it is the most practical and cost-effective method. With an enhancement in the wt % of reinforcement with an Al base matrix, mechanical and physical properties including hardness and compressive strength were noticeably improved. However, because of the cracking and debonding that takes place at the.

interface between the reinforcement and the aluminium matrix as a result of the increased TiC content in the aluminium matrix increases the mechanical properties [3].Selvakumar et al. [4] used stir and ultrasonic cavitation assisted casting techniques to add micro and nano B4C carbide grains to an aluminium matrix, reporting that perhaps the nano composites had superior tension force, stiffness, and impact energy than the micro B4C particulate composites.Cao Fenghong et al. investigated an experimental work on Al6061/SiC/WC, the composites was fabricated through stir casting process and the mechanical properties of developed composites were analyzed.Due to the presence of tungsten carbide and SiC the tensile and hardness increases with increase in hard particulates present in matrix.Hybrid Al6061/SiC composites reinforced with tungsten carbide (WC)., the SiC particle (μm) content is held constant at 5 wt% while the WC particle (35 μm) content is altered from 0 to 6 wt% in steps of 2 wt%. According to the outcomes, the wear rate (microns) reduced even as WC content is higher up to 4 wt%; later, it sharply increased at 6 wt% WC. In contrast, the final tensile strength, hardness, and corrosion resistance of the composite materials are improved as the the material of WC [5].Bhargavi Rebba investigated the mechanical properties of Al 2024/ MoS2 MMCs. The MoS2 particulates are taken in weight fraction of 1,2,3,4,5 percentages with the base materials. The results analyzed that at 5 % of MoS2 has better tensile and hardness and uniform distribution of reinforcement in matrix material [6–10]. Tungsten

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carbide (WC) particles, MoS2, and Al7075 are used as reinforcing particles. The stir-casting process is used to create the make the composites. On a mass fraction basis, WC particulate was added to the molten metal in proportions of 2 %, 4 %, 6 %, 8 % and 10 %, and MoS2 was added in a relates to the amount of 4 %. According to the findings, the generated MMCs ' hardness and tensile strength increase as the weight % of WC increases; however, between 8 % and 10 %, the hardness starts to decline [11–14]. From the above literature the influence of MoS2 and tungsten carbide and reinforced with different aluminium matrix material.While adding the reinforcements to the matrix materials the mechanical properties increases.

2. Experimental setup

Al6262has chosen as a base material with good material propertieshighcorrosionresistance and superior welding properties [8].MoS2 is chosen as a reinforcement due to its self lubrication properties. The chemical composition of the base material is shown below in Table 1. The composition of the selected mixtures of base materials are Sample A: 95 %AL6262 – 2 %MoS2 – 3 % WC,Sample B: 90 %AL6262 – 4 %MoS2 – 6 % WC, Sample C: 85 %AL6262 – 6 % MoS2. – 9 % WC, The hybrid composite of Al6262-WC-MoS2 were prepared by stir casting technique as shown in Fig. 1.

The reinforcement is heated for 20 min at 450 °C before being cast. The Al6262 was melted in a graphite crucible at 600 °C-700 °C after preheating the reinforcement. [9] The reinforcement is then mixed with the aluminium matrix, and magnesium is added at 2 % with aluminium foil to prevent explosions, and the mixture is agitated for 5 min at 750 rpm [15–19].

2.1. Mixing ratio

In our project Aluminum and silicon carbide mixed below mentioned categories Sample1: 95 %AL6262 – 2 %MoS2. – 3 % WC.

Sample2: 90 %AL6262 – 4 %MoS2.. – 6 % WC.

Sample 3: 85 %AL6262 – 6 %MoS2.. – 9 % WC.

3. Result and discussion

3.1. Impact test

Fig. 2 shows the graph of impact test results.The impact tests was conducted using charpy impact test. The composition of 95 %AL6262 –2%MoS2. – 3 % Tungsten carbide the tensile value shows 6.67 N. The tensile value for 90 %AL6262 – 4 %MoS2.. – 6 % WC is 13.3 N. Meanwhile 90 % AL6262 – 6 %MoS2.. – 9 % WC is 17.34 Mpa.The maximum impact value is observed at maximum percentage of tungsten carbide and MoS2.The impact strength less than that of the pure Al6262 alloy, possibly because the atoms prevented the crystal lattice from moving. The grain's boundaries can be a potent impediment to dislocation motion. The interface between the uniformly distributed reinforcement and the matrix alloy has implied that the impact strength has been linearly improved in addition of reinforcement. In the matrix alloy, the presence of stronger reinforcing particles (WC and MoS2) creates barriers that limit the motion of dislocations and plastic flow [20–25].

Fig. 1. Stir casting experimental setup.

3.2. Hardness test

A method known as "microhardness testing" was used to measure a composite hardness using a microscopic band as a reference. The MVH-II advanced miniaturised scale hardness equipment was used to evaluate hardness value. A diamond boulders indenter is placed on the material to be tested in this instance, ranging in size from a few grams and the microhardness estimate is evaluated using the applied load [12]. Fig. 3 shows the graph of hardness test results.The hardness tests was conducted using vickers micro hardness. The composition of 95 %AL6262 –2%MoS2. – 3 % Tungsten carbide the hardness value shows 47.53HV. 90 %AL6262 – 4 %MoS2.. – 6 % WC the hardness value is 60.03 HV. Meanwhile 90 % AL6262 – 6 %MoS2.. – 9 % WC is 74.34 Mpa.The maximum hardness value increases with amount of percentage of reinforcement added to the matrix material. When the increase in Tungsten carbide and MoS2 the hardness value is higher due to which the density of the composites is higher at addition of maximum reinforcement to the matrix [26–29].

3.3. Tensile test

Fig. 4 shows the graph of tensile test results of developed aluminium composites. The composition of 95 %AL6262 –2%MoS2. – 3 % Tungsten carbide the tensile value shows 185 Mpa. The tensile value for 90 %AL6262 – 4 %MoS2.. – 6 % WC is 197.3 Mpa. Meanwhile 90 %AL6262 – 6 %MoS2.. – 9 % WC is 207.6 Mpa.The maximum tensile value is observed at maximum percentage of tungsten carbide and MoS2 [30–34]. Due to the presence of MoS2 the matrix material become ductile and maximum elongationoccurs.The improvement in tensile strengths of AHMMCs is attributable to the materials' reinforcing effect at strain differences, improved interfacial interaction, grain size, and lateral load mechanisms between both the and reinforcement particles [35]. The presence of Tungsten Carbide in the aluminium matrix acts as a location for deposition, and the crystallisation of exiting particles causes the aluminium matrix to recrystallize [36–39].

3.4. Micro structure

Fig. 5 shows the different composition of developed aluminium composites, Fig. 5a have the composition of 95 %AL6262 –2%MoS2. – 3 % Tungsten carbide from the scanning microscopic images it is

Table 1
Typical chemical composition for aluminum alloy 6262.

Si	Fe	Cu	Mn	Mg	Zn	Ti	Cr	Al
1.12	0.25	0.08	0.75	1.05	0.15	0.10	0.23	Bal

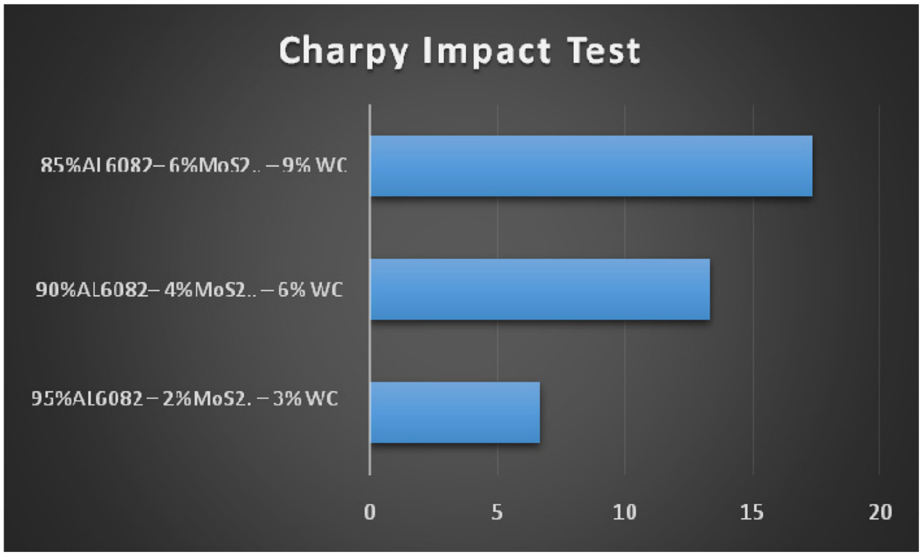

Fig. 2. Charpy Impact Test.

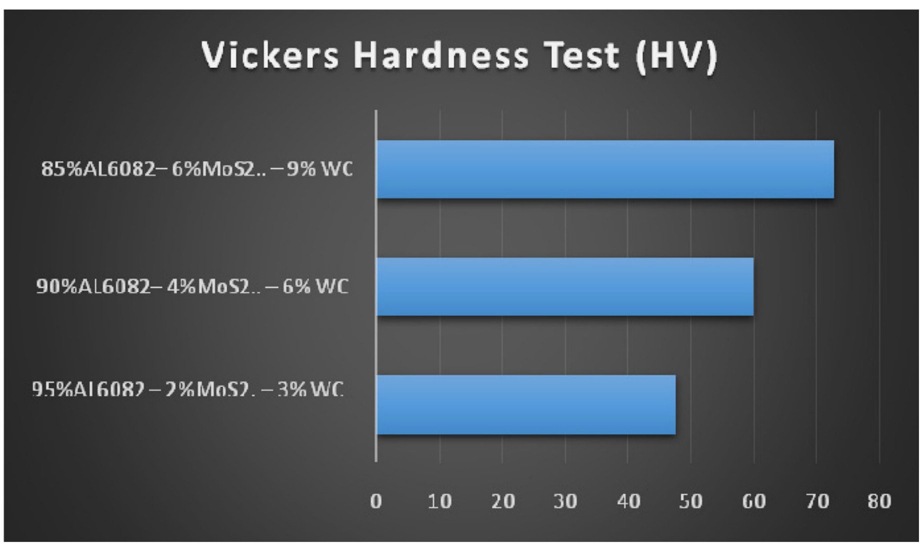

Fig. 3. Vickers Hardness Test.

inferred that very few particles of tungsten carbide are dispersed in the matrix.Neutral - point like Mg2Si and Zn-Al2 are used to dissolve the grain structure. Just at crystal structure, they solidify as inter - metallic complexes. At the grain borders and within primary aluminium particles, the composites' few particles of tungsten carbide and MoS2 particles are clearly defined. Meanwhile Fig. 5b shows 90 %AL6262 – 4 %MoS2.. – 6 % WC are dispersed to the base material.in medium level. Additional strengthening particles were visible in the matrix when more Tungsten carbide and MoS2 was added in composite formulation. The Figure illustrates how these particles usually occupied the microstructural places. The eutectic particles also contained the grain size. The grains in the matrix determines addition of tungsten carbide particles are present in aluminium matrix. In the other hand the maximum distribution of the reinforcement is shown in the Fig. 5C. The combination are 85 %AL6262 – 6 %MoS2 – 9 % WC. From the image it can be found that the MoS2 whiskers are found in most of the matrix material in 6 %MoS2 and 9 % tungsten carbide.Increase in Tungsten Carbide content took up more space in the matrices and obscured the presence of MoS2, which is depicted in Fig. 5c. Fig. 5C illustrates how the composite components are clearly resolved at the grain borders and within primary aluminium grains by increase in reinforcement particles. Because of their greater density, the increased WC addition in the molding caused particles to agglomerate while the dispersion of MoS2 in the matrices is homogeneous.

4. Conclusions

Based on our work it is found that the weight to strength ratio for Aluminium 6262 Molyndenum di-sulphide – Tungsten carbide during hardness and impact test to be compared with the different composition and it can be used for aircraft applications. With conducted three composition the 85 %AL – 6 %MoS2 – 9 %WC based specimen's was provide more impact and hardness which means that the higher amount of molybdenum and tungsten carbide was increased the mechanical strength of aluminum composite. The microstructures results shows that the combination of 85 %

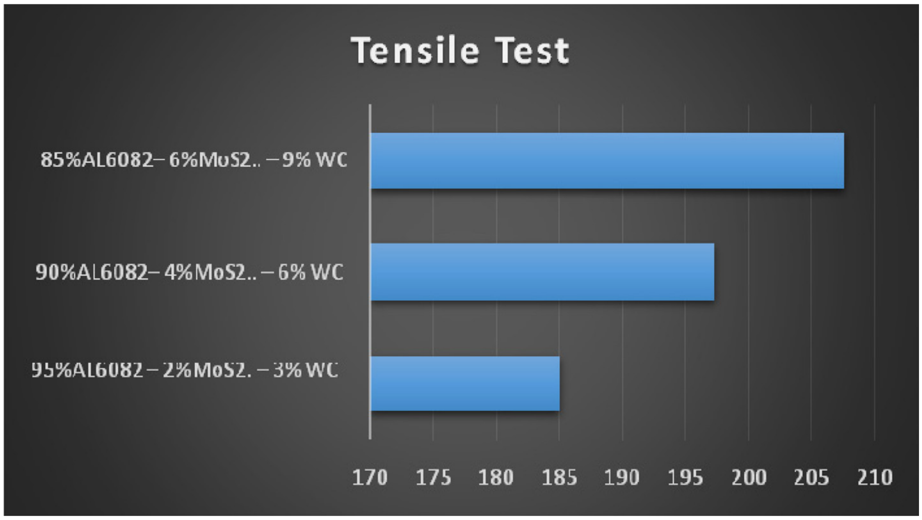

Fig. 4. Tensile Test.

MICRO STRUCTURE

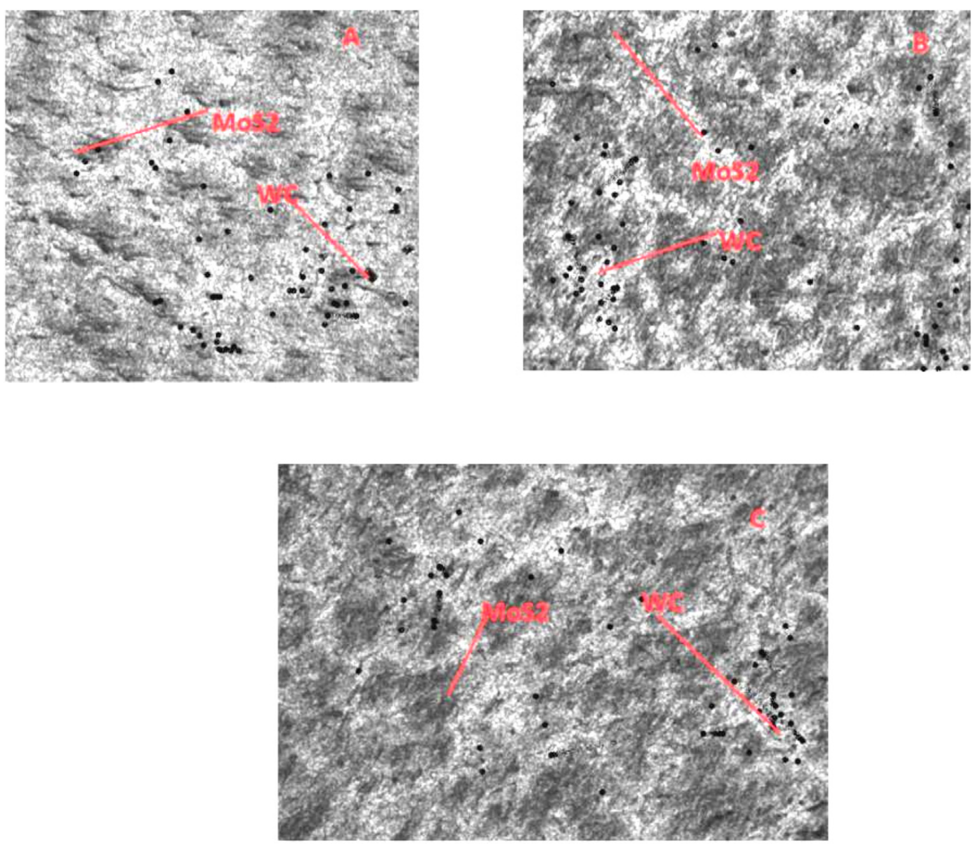

Fig. 5. Microstructure of Al6262 + MoS2 + WC Composites.

AL6262 – 6 %MoS2 – 9 % WC. From the image it can be found that the MoS2 and WS whiskers are distributed in most of the matrix material.

CRediT authorship contribution statement

Kadapa Hemadri: Formal analysis. **Ajith Arul Daniel S:** Conceptualization, Data curation. **Vijayendra Kuknur:** Investigation, Methodology. **Vijayananth S:** Validation. **Kumar R:** Review & editing.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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